CATION CONTENT OF STEMFLOW IN SOME FOREST TREES IN NORTH CAROLINA

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Introduction

A portion of the precipitation intercepted by the forest canopy is recycled into the atmosphere as evaporation. The remainder is absorbed by the crowns, drips off the foliage, or funnels down the branches and trunk to reach the ground as stemflow. The proportion of this latter component of interception in relation to total precipitation has been reported as ranging from 1 to 20 per cent depending upon forest type, density, time of year, and intensity of precipitation (Geiger, 1950; Rowe and Hendrix, 1951; Hoover, 1953; Ovington, 1954; Voigt, 1960b).

Though there is evidence that the precipitation intercepted by the foliage and coming down the stems removes nutrients, very little data are available as to the contribution of the stemflow to the nutrition cycle of trees. Tamm (1951) studied the removal of nutrients from tree crowns by rain and found that considerable amounts of Ca, K, and Na were removed by the rain water collected underneath pine, oak and birch trees along with smaller amounts of N and P. Stenlid (1958) also mentions considerable loss of salts from tree canopies by rainfall. Pozdnyakov (1956) determined the acidity, dry matter and ash content of stemflow from pine, birch, and larch which was acidic, acidity being greater in pine than in birch and larch. He also found that stemflow alters certain soil properties at the base of the tree. Voigt (1960a) determined N, P, K, and Ca content of rain water, throughfall, and stemflow in red pine, hemlock, and beech stands near an industrial area in Connecticut. He found that the composition of rain water was altered by the trees; the degree of alteration was affected by season, species, and location of collection with respect to the trees.

The present study was undertaken to investigate the cation content of stemflow from four different species of trees in the Duke Forest (a non-industrial area) in the Piedmont of North Carolina. In this way, an approximation could be obtained of the amounts of certain nutrients recycled to the soil through this component of interception.

Materials and Methods

Twelve trees, three each of loblolly pine (*Pinus taeda* L.), dogwood (*Cornus florida* L.), yellow-poplar (*Liriodendron tulipifera* L.) and red maple (*Acer rubrum* L.), were selected in the Duke Forest and stemflow obtained for all the trees for five storms ranging in size from 10.2 mm to 26.2 mm (0.4 inches to 1.03 inches) between November 9, 1964, and December 13, 1964. Each tree was equipped with a spiral gutter made of aluminum foil, and fixed to the tree at breast height by means of modeling clay after the bark had been smoothed for some distance at the point of fixing the gutter. Stemflow was collected in clean plastic buckets, hung on the trees, through a spout made in the gutters. Rain water was collected in a plastic bucket (rimmed with modeling clay) in an open plot near the forest; all the trees except the pines had shed their leaves.

In order to minimize the rainfall falling directly into the gutters, and the buckets (meant for collecting stemflow) the gutters were made narrow and the buckets covered with an aluminum foil lid. After each storm, stemflow from each tree and rain water from the open were collected and analyzed for Ca, K, and Na with a Coleman flame photometer.

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Results and Discussion

The results of the chemical analysis of stemflow as compared with rain water are shown in Table I. These figures indicate that there is considerable variation in the concentration of different cations between species and also within a species.

The cation content in all the species studied decreases in the order of K, Ca, and Na. That of yellow-poplar contains 15 and 5 times more K and Ca, respectively, than Na. Potassium content in red maple stemflow was double that of Ca and six times that of Na. Dogwood had the same amounts of K and Ca which were about twelve times that of Na. Potassium concentration in loblolly pine was twice that of Na and slightly more than Ca.

The highest average values for K were obtained for yellow-poplar followed by dogwood, pine, and red maple, there being no significant difference between yellow-poplar and dogwood and between pine and red maple. Yellow-poplar contained over 25 times more K than rain water and three times more than red maple. Dogwood behaved in a similar fashion.

Though the potassium concentration of stemflow from two trees of red maple was relatively low (average 3.8 ppm), another red maple tree showed consistently higher values for K for all the storms (average value for K for all the storms being 12.6 ppm) indicating considerable variation in cation concentration within individuals of the same species. The possibility exists that the potassium uptake of this particular tree was greater because its roots are in contact with a substrate high in potassium.

Stemflow obtained from dogwood had the highest Ca content followed by yellow-poplar, pine and red maple. There was no significant difference between yellow-poplar and red maple. Dogwood contained 14 times more Ca than rain water, five times more than red maple and more than twice that of yellow-poplar and pine.

Loblolly pine stemflow had the highest concentration of Na followed by the three deciduous species with much lower amounts. Pine had ten times more Na than rain water and three times more than the hardwoods. There was no significant difference between the Na content of rain water and that of the three hardwood species.

The cation concentration of the stemflow collected from the three hardwoods may be somewhat higher at other seasons of the year, when the trees are in full foliage. This would be especially true in case of dogwood and yellow-poplar whose foliage is high in mineral nutrients, such as K and Ca (Voigt, 1960a).

Cation concentrations obtained for rain water are very generally in agreement with those reported earlier (Gorham, 1955 and 1961; Hewitt, 1952; Tamm, 1951; Voigt 1960a), the differences being attributed to the fact that the mineral content of rain water varies considerably according to location, season (time) and means of sampling, amount of rainfall, and source of the airmass.

Table II shows the sodium content of rain water and stemflow collected from different species on December 13, 1964. The sodium values for this storm were higher for rain water than the average values reported in Table I. This high sodium content is reflected in the stemflow. The most probable reason for the high sodium values on this date appears to be that the precipitation originated in a maritime tropical airmass whose source was the Gulf of Mexico and the Caribbean Sea (as evidenced by U.S. Daily Weather Maps for the preceding week). It appears likely that the measured sodium was the result of salt spray from waves and breakers along the coasts of the Gulf of Mexico and the Caribbean Islands. It has been reported elsewhere that the source of sodium in rain water is such coastal salt spray (Gorham, 1955, 1958, and 1961; Mordy, 1953). However, recent measurements of sodium atoms in the upper atmosphere showing both seasonal and anomalous peaks of abundance may indicate that the sodium also has other sources and its atmospheric cycling is more complex than that suggested earlier (Hunten, 1964; Burnett, 1965).

The redistribution of precipitation due to the concentration of water at the base of the trees through stemflow is believed to be of significance to soil moisture and consequently to tree growth. The importance of stemflow as a direct contributor in recharging the moisture content of the soil just at the base of the tree bole, especially under milder storms and where conditions are favourable for infiltration has been discussed by various authors (Dabral and Nath, 1962; Hoover, 1953; Leonard, 1961; Voigt, 1960b; Pozdnyakov, 1956).

The present study has indicated that quantities of minerals, especially K and Ca, are leached through stemflow, particularly from hardwoods such as yellow-poplar and dogwood even in leafless condition. These nutrients are returned to the soil around the bases of tree trunks. Such recycling of ions through stemflow could have a significant role in maintaining tree growth on nutrient-poor soils.

TABLE I

Cation Content of Stemflow

(Average values for five storms and three trees per species)

	Cation Content (ppm)		
	K	Ca	Na**
Yellow-poplar (*Liriodendron*)	10.9	3.6	0.7
Dogwood (*Cornus*)	8.8	8.7	0.7
Red maple (*Acer*)	3.8*	1.7	0.6
Loblolly pine (*Pinus*)	4.1	3.3	2.1
Rain water	0.4	0.6	0.2

*Values are average of two trees only, the third tree being discussed separately in the text. If values from all three trees are averaged, the mean would be 6.8.

**Values are average of four storms only, the fifth storm being discussed separately in the text.

TABLE II

Sodium Content of Stemflow on Dec. 13, 1964

(Stemflow values are averages of 3 trees per species)

Species	Na (ppm)
Loblolly pine	3.4
Red maple	1.9
Dogwood	1.4
Yellow-poplar	1.4
Rain water	1.2

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